PATENT SPECIFICATION

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DRAWINGS ATTACHED

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(54) MANUFACTURE OF GLASS

(71) We, FORD MOTOR COMPANY LIMITED, of 88 Regent Street, London W.1., a British Company, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a process for the manufacture of flat glass by the "float" process: in this process a glass ribbon is formed on the surface of a molten bath to obtain true parallelism of the opposite faces and a lustrous, fire-polished surface finish.

The molten bath is contained within a chamber in which a controlled, protective atmosphere is maintained above the bath. After forming, the ribbon of glass is advanced along the surface of the bath and is progressively cooled to permit the ribbon to harden sufficiently so that it may be taken off at the end of the bath on more or less conventional rollers without injury to its surface. The ribbon is then passed through an annealing lehr and is further processed in a conventional manner.

At the temperatures at which the bath is operated (up to 1800°F.), most metals are subject to rapid oxidation of the surface exposed to the atmosphere. Formation of surface oxide usually has a deleterious effect on the underside of the glass ribbon and, therefore, a nonoxidizing, protective atmosphere is employed over the molten bath to minimise such oxidation and formation of defects on the surface of the glass. The protective atmosphere comprises a nonoxidizing gas, usually nitrogen, that does not chemically react to any substantial extent with the molten metal of the bath.

It is usual to use a bath consisting at least principally of tin. Molten tin at elevated temperatures oxidizes rapidly in the presence of even a small amount of oxygen, and it has been demonstrated that the presence of even a small amount of tin oxide on the surface of the bath causes a migration of tin into the glass which, upon further processing, causes an objectionable iridescent bloom on the surface of the glass that was exposed to the tin.

In addition, there is a tendency for particles to drop onto the glass ribbon before it is hardened and cause defects commonly identified as "top speck" or "drip". These surface defects appear to be the result of drop-off of materials which have condensed onto coolers, onto the underside of the chamber roof and onto other structural components above the ribbon and eventually drop off to become embedded in or deform the upper surface of the ribbon. These compounds are probably sulphides and oxides that are formed within the chamber. It is believed that the sulphur is introduced into the chamber with the glass from the melting furnace and that the oxygen leaks into the chamber from the outside atmosphere or possibly as a result of a small amount of breakdown of some of the oxide constituents of the glass. Also, there is a certain amount of tin which is vapourized at operating temperatures of the chamber and may tend to condense on surfaces above the ribbon.

According to the present invention, a non-oxidizing but not reducing atmosphere within the chamber is recycled through a cleansing system to remove from the atmosphere some at least of the contaminants liable to cause "top speck" and "drip".

In a preferred embodiment of the invention, the atmosphere is continuously removed from the higher temperature zones of the chamber and passed through the cleansing system, which may comprise activated carbon filters, scrubbers, compressors, catalyst chambers and dryers in any combination before being returned to the chamber. The cleansing system is separate from the chamber so that removal of contaminants can be carried on as a continuous process without affecting the production of the float glass ribbon.

Each of the appended claims also describe the invention. The invention is hereinafter particularly described with reference to the accompanying drawings in which:

Figure 1 is a diagrammatic vertical section

of a chamber for the manufacture of float glass;

Figure 2 is a diagrammatic plan view of the chamber;

Figure 3 is a diagrammatic side elevation cf the chamber; and

Figure 4 is a diagram of a system for cleansing the protective atmosphere of the chamber before returning it to the chamber.

In the manufacture of glass by the float process, glass, which is usually of more or less conventional composition, e.g. soda-lime glass, is produced in a conventional type of melting and refining furnace and discharged onto the surface of a bath of molten metal, preferably molten tin with or without alloying elements. The glass spreads to form a layer of uniform thickness floating on the surface of the tin, and by cooling the glass and removing the ribbon at a uniform rate, a ribbon of uniform width and thickness can be produced. The temperature in the chamber decreases progressively towards the exit end so as to cool the ribbon sufficiently so that it can be taken off at the exit end of the chamber by more or less conventional rolls without marking the surface of the glass. The glass thus obtained has an excellent fire-polished surface finish and is of good optical quality.

A glass 12 is melted and refined in a more or less conventional glass furnace 11. A constant level of molten glass 12 is maintained within the furnace and issues through a forehearth 13 into an enclosed chamber 14, a gate 15 being used to control the rate of flow of glass from the furnace. The chamber 14 holds a bath 16 of molten tin on which the glass is floated to form a continuous ribbon 17.

The tin bath 16 is contained in the bottom of the chamber 14 by refractory blocks 18. The chamber 14 is formed of side walls 19, end walls 21 and 22 provided with exit and entrance openings respectively and a roof section 23 spaced from the surface of the tin bath 16 to form a head space or plenum 24. The bottom of the chamber 14 may, if desired, have a liner 35 formed of carbon.

The chamber 14 is heated largely by heat from the molten glass introduced into the chamber at a temperature of about 1850°F. A series of electric heaters 26 and coolers 27 are carried by the roof section to add or remove heat in order to obtain the necessary gradation of heat to initially permit the glass to flow to uniform thickness across the width of the ribbon and later, to cool the ribbon sufficiently (to about 1100°F.) to permit its removal without marring the surface of the glass. Local cooling may also be used to maintain the ribbon at less than equilibrium thickness, to which it tends to return under the influence of gravity and surface tension, and to equalize the temperature acrcss the width of the ribbon.

A non-oxidising but not reducing atmosphere is employed in the plenum 24 to protect the molten tin against oxidation. The atmosphere, which is supplied to the chamber 14 through inlets 28 in the roof section 23, is preheated to about 1000°F. and is additionally heated by the heaters 26 within the chamber. A small volume of atmosphere is continually added to the chamber to make up for losses at the exit opening for the ribbon 17 and for other losses.

The ribbon of glass 17 passes through the chamber 14 and through an exit opening in the end wall 22 of the chamber. The exit opening has a seal, and the atmosphere within the chamber is maintained above atmospheric pressure to retard the ingress of outside atmosphere to the chamber. The ribbon 17, immediately after leaving the chamber 14, enters an annealing lehr 29 where it is further cooled under controlled conditions to remove residual stresses and facilitate cutting and further fabrication of the glass. A series of rolls 31 are installed in the lehr 29 to support and advance the ribbon.

The non-oxidizing but not reducing atmosphere within the chamber 14 substantially reduces defects in the glass caused by the presence of tin oxide. The atmosphere, however, does not tend to become contaminated and, also, problems have been encountered with damage to the top surface of the ribbon by defects commonly referred to as "top speck" and "drip". These defects appear to be the result of drop-off of metallic tin and tin sulphides and oxides which may form in or be absorbed by the atmosphere and tend to condense on the water coolers 27, heaters 26 and other exposed structural portions of the roof 23 of the chamber. It is possible that the atmosphere may at times reduce these compounds or tend to dislodge them so that they fall on the top surface of the ribbon 17. Also, vibration or adjustment of the coolers or other structures may loosen the built-up materials and cause them to drop onto the ribbon.

It has been found that "top speck" or "drip" can be greatly reduced or virtually entirely eliminated by circulating the atmosphere from the chamber 14 through a purification system and then reheating the gas and returning it to the chamber. This has the result of preventing the buildup of oxygen and sulphur compounds within the atmosphere and removing any tin vapours which may be present.

As best seen in Figures 2 and 3, the "used" atmosphere is preferably removed from the hotter zones of the chamber 14 through a series of 3-inch pipe lines 33 on either side of the chamber. Preferably, the lines are fixed to the side walls of the chamber about 18 inches above the surface of the molten bath. Control valves 35 in each line permit

regulation of withdrawal of the used atmosphere. The hotter zones are defined as the first sections of the chamber in which the temperatures range from about 1850°F. to about 1400°F.

The atmosphere, after being restored by the gas cleansing system, is returned to the chamber through a return line 36 which communicates through a number of branches 37 with the hotter zones of the chamber. The branches are fixed in the roof section 23 and are offset longitudinally of the chamber from the outlets 33, as shown in Figure 2: that is a branch 37 does not lie on the same transverse line as an outlet 33. Valves 39 in the outlet parts 28 of the branches regulate the flow through the branches 37. If desired a flow meter 38 may be inserted in each branch.

It has been found especially advantageous to withdraw contaminated atmosphere from the two bays of the chamber adjacent the entrance where the temperature is hottest (about 1850°F.) and to return the restored atmosphere to bays where the temperature is in the range of about 1600°F.—1400°F., this zone being a short distance from the hottest zone at the end of the chamber. There seems to be a greater tendency for "top speck" and "drip" to occur in the hottest zones of the chamber due to condensation above the ribbon at a higher rate in these areas. In addition, the ribbon 17 is softer in this area and more subject to marking.

A preferred embodiment of the purification system 32 is schematically indicated in Figure 4.

The contaminated atmosphere removed through the lines 33 is received at approximately 1000°F. and 0.5 inches water column in a conventional water scrubber 41 that cools the atmosphere to approximately 80°F. to condense out SnO_2, SnS and other vapour impurities. The atmosphere then passes through a water separator 42 to remove any liquid from the gas stream and continues to a snubber 43 that serves as an inlet vessel for a compressor 44. The snubber 43 also serves as a secondary separator and contains a filter. The compressor 44 serves for withdrawing the atmosphere from the plenum 24 and for returning the purified gas to the plenum.

After being compressed, the atmosphere is passed through a water cooler 45 to cool the gas to about 80°F., after which it is passed through a second water separator 46 and a charcoal filter 47 intended to chemically absorb any sulphur impurities not removed by the water scrubbers. The atmosphere then continues through drying towers 48 which remove moisture from the gas by an activated alumina desiccant which preferably lowers the dew point of the gas to about −70°F. A mechanical filter 49 then removes any minute particle of activated alumina which may have been picked up from the drying towers 48. The dried gas may be heated to about 550°F. in a heater 51 for activation in a catalyst chamber 52 to reduce the oxygen content of the gas back to approximately 1 PPM. The purified gas is then cooled by a cooler 53 to about 80°F. and passed through a pressure regulator 54 to the return line 36 which returns the cleansed atmosphere to the chamber 14 where it is heated upon entering the plenum 24.

Almost all the impurities accumulating in the atmosphere are removed by recycling the gas through the scrubbing and purification system in order to maintain the atmosphere in the plenum free of oxide and sulphide contaminants and, therefore, prevent the formation of condensates in the chamber that may cause surface defects on the upper face of the glass ribbon 17. By taking the atmosphere from the hottest portion of the chamber 14 and restoring it to an adjacent portion of the chamber, the impurities, usually in vapour form, present in the atmosphere are removed rather than being permitted to build up within the chamber and adversely affect the quality of the glass.

WHAT WE CLAIM IS:—

1. A process for manufacturing flat glass. The process according to this claim comprises: floating a continuous ribbon of glass on a bath of molten metal within an enclosed chamber; maintaining a nonoxidizing but reducing atmosphere within the chamber above the glass and molten metal; and recycling a portion of the atmosphere within the chamber through a cleansing system to remove some at least of the contaminants liable to cause "top speck" or "drip" from the atmosphere.

2. A process according to claim 1 in which the cleansing comprises scrubbing and purification.

3. The process according to claim 1 or claim 2 in which the bath comprises principally molten tin.

4. The process according to any of the preceding claims in which: the ribbon is formed adjacent one end of the chamber at a temperature of about 1800°F. and is cooled along the length of the chamber and leaves from the other end of the chamber at a temperature of about 1100°F; and the atmosphere to be cleansed is removed from and replaced in the zones of the chamber adjacent its hotter end.

5. The process according to any of the preceding claims in which the atmosphere is removed from the chamber through the side walls and returned into the top of the chamber through the roof section.

6. The process according to any of the preceding claims in which the atmosphere is removed from the hottest portion of the chamber and replaced in adjacent zone of the

chamber operated at a temperature at least two hundred degrees cooler than the zone at which it is removed.

7. The process according to any of the preceding claims in which the cleansing system also removes moisture to lower the dew point of the atmosphere below 0°F. before being returned to the chamber.

8. A method of making float glass substantially as hereinbefore particularly described with reference to the accompanying drawings.

9. Glass made by the method according to any of claims 1 to 8.

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1211225 COMPLETE SPECIFICATION

4 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

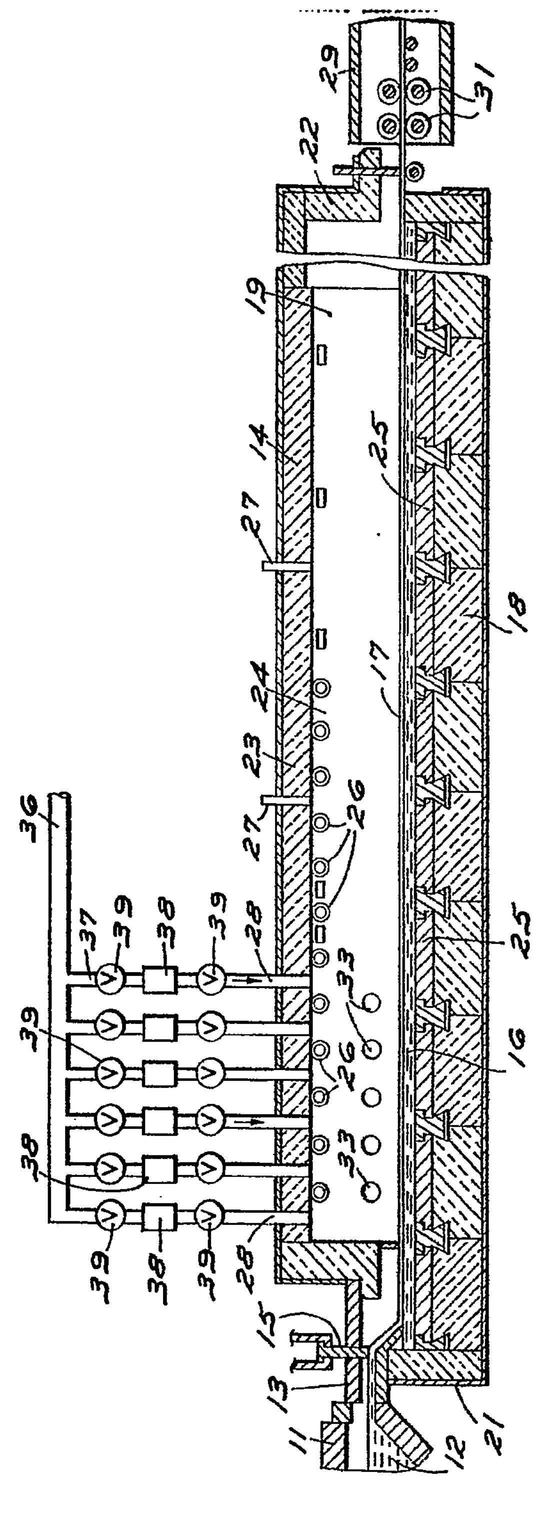


FIG. 1

1211225 COMPLETE SPECIFICATION

4 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 2

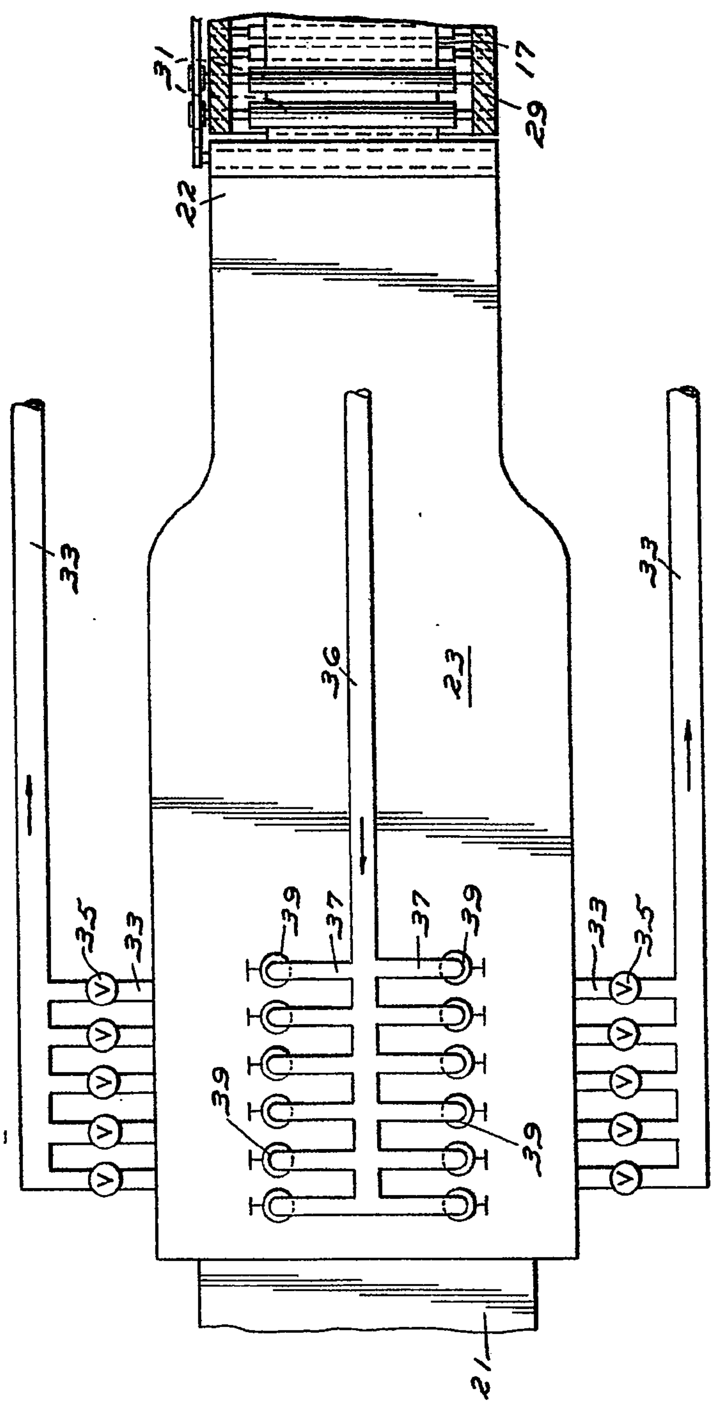
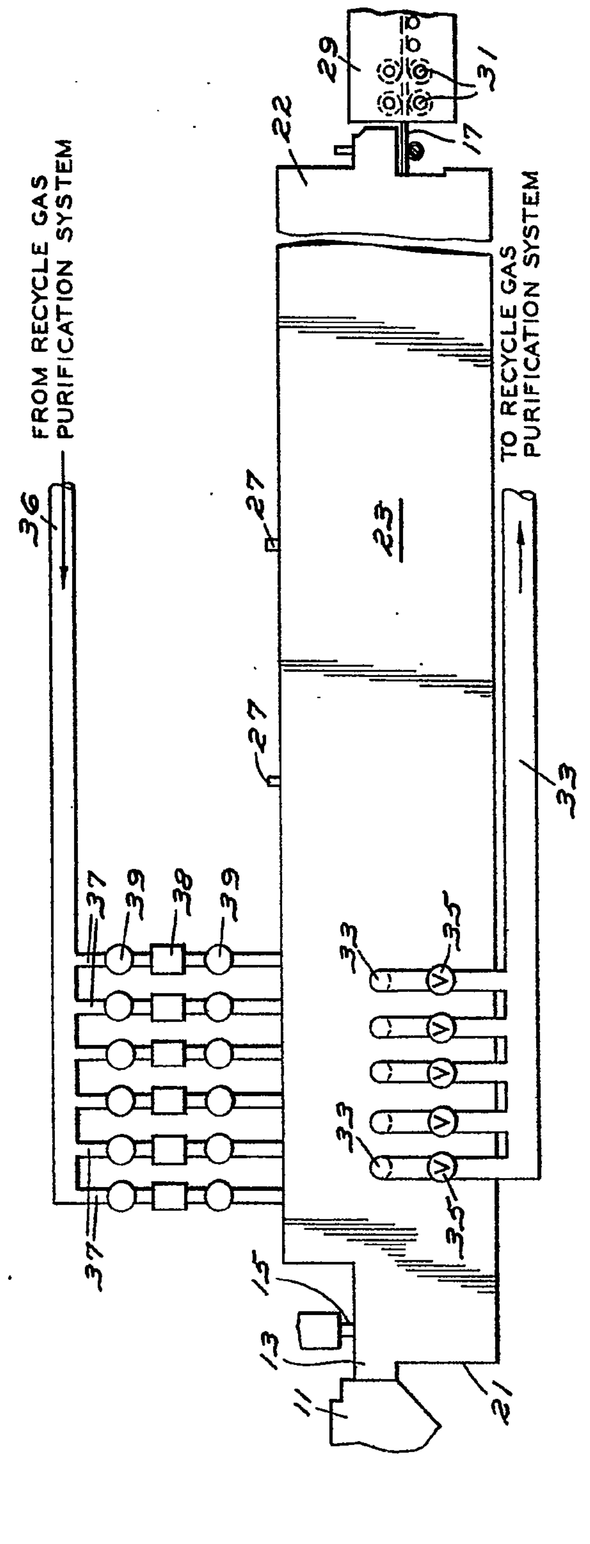


FIG. 2


FROM RECYCLE GAS PURIFICATION SYSTEM
TO RECYCLE GAS PURIFICATION SYSTEM
29
31
22
17
36
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11
21

FIG. 3

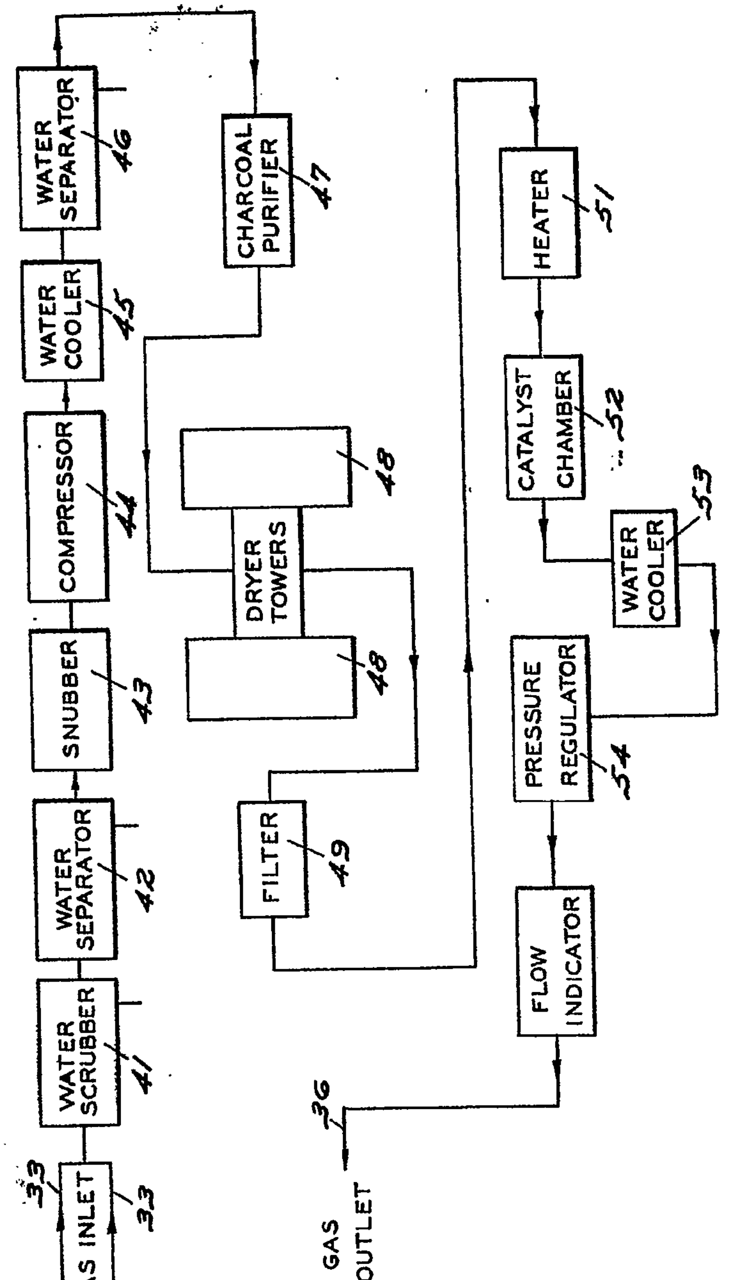
GAS INLET
33
33
WATER SCRUBBER
41
WATER SEPARATOR
42
SNUBBER
43
COMPRESSOR
44
WATER COOLER
45
WATER SEPARATOR
46
CHARCOAL PURIFIER
47
DRYER TOWERS
48
48
FILTER
49
HEATER
51
CATALYST CHAMBER
52
WATER COOLER
53
PRESSURE REGULATOR
54
FLOW INDICATOR
36
GAS OUTLET

FIG. 4